

Electrochemical Behaviour of Active Surface Layers in Rolled Aluminium Alloys Sheets

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During production of aluminium sheet, the surface of the material is subjected to different thermo-mechanical treatment than the bulk. The highly deformed layer at the surface has characteristically different microstructural features compared to the bulk. Submicron level grain sizes are produced in this region. Filiform corrosion behaviour of automobile and architectural aluminium alloys is predominantly controlled by the presence of this micro-deformed (micro-grained) layer at the surface causing the precipitation of fine intermetallic phases of impurity elements during subsequent heat treatment. The presence of micro-deformed (micro-grained) layer provides numerous sites for nucleation of intermetallic phases during heat treatment. Hence it is important to understand electrochemical behaviour of this deformed layer at the surface in comparison with the bulk in aluminium sheet alloys because of its relation to filiform corrosion. The thickness and nature of the micro-deformed layer changes with deformation levels and heat treatment.

In the present work, the micro-deformed layer at the surface of rolled super purity Al-Fe-Si-Mn model alloys were electrochemically characterized. The electrochemical measurements were carried out on material at different depth from the surface as well as in the bulk. The material was etched to different depths using GDOES (Glow discharge optical emission spectroscopy) sputtering. The experimental techniques used were potentiodynamic anodic and cathodic polarization, free corrosion potential measurements, potentiostatic and galvanic coupling experiments. All the studies were carried out in 5% NaCl at pH 3.0 and 11.5. Intermetallic particle volume and area fractions at different depths in the micro-deformed layer and in the bulk were measured using image analysis of SEM back scattered pictures and correlated with electrochemical behaviour at different depths. The solid solution composition of the alloys was measured using thermo electric power measurements. The morphology of corrosion attack was observed using SEM, EDX and White light interference microscope (Wyko). A replica technique was used for revealing the internal structure of the pit; analysed using Wyko.

The thickness of the micro-deformed layer in a 1.5 mm thick sheet was found to be approximately 1 μm . The anodic and cathodic reactivity (Figs. 1 and 2) of the micro-deformed layer was found to be significantly higher than that of the bulk. The former is attributed to the depletion of more Mn at the surface as a result of higher precipitation while the latter is due to more number of intermetallic particles. In agreement with this, the image analysis revealed a higher level of fine intermetallic particles in the micro-deformed layer. The volume and area fraction of intermetallic particles showed a decrease

from surface to interior. The corrosion morphology of the surface layer showed smaller pits while the larger pits were observed in the bulk. The potentiostatic and dynamic polarization experiments in alkaline solutions showed that the localised attack is easy on surface. The magnitude of passive current density for the surface was almost double that of the bulk. However the repassivation of pits in the micro-deformed layer was easier due to the smaller pit size. Anodically polarized specimens showed crystallographic pitting both in pH 3.0 and pH 11.5, indicative of acidic pitting above the breakdown potential while cathodically polarized specimens revealed alkaline grooving around intermetallic particles. Interestingly, the groove formation around the particles depends on the type of particles with increasing Mn content reduces groove formation. Wyco 3D-interactive image of the replica also showed crystallographic dissolution with in the pits with a terraced internal structure.

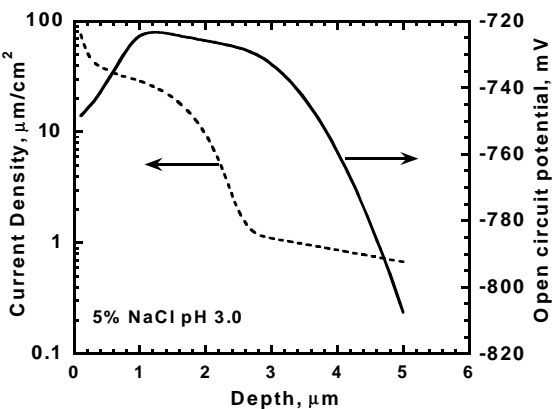


Fig. 1 Cathodic current density at -1.0 V vs SCE and OCP for Al-0.4Fe-0.3Si-1.0Mn alloy at different depths from the surface etched using GDOES

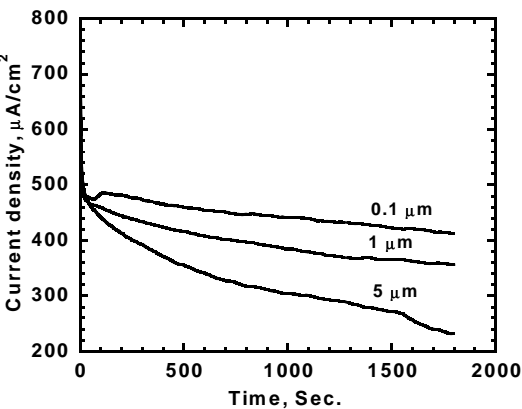


Fig. 2 Current density at -0.8 V vs SCE for Al-0.4Fe-0.3Si-1.0Mn in 5% NaCl pH 11.5 at different depths from the surface etched using GDOES

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